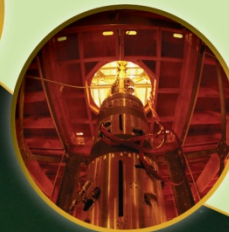
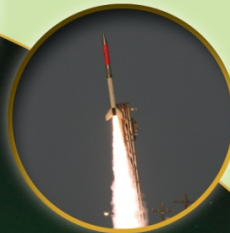


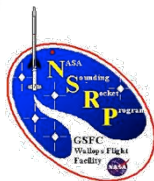


Black Brant Rocket Motors

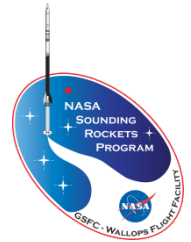


Sounding Rocket Working Group

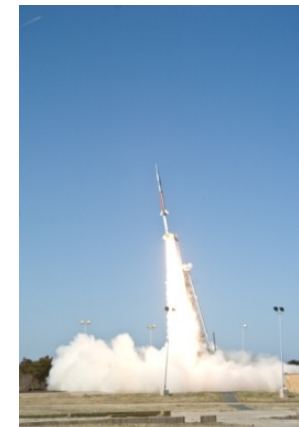
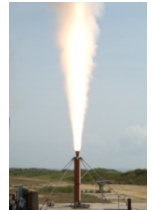
June 10, 2010



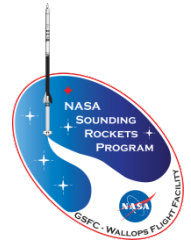
Terrier/Improved Malemute Development Effort



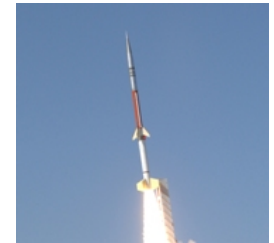
- Static firing July 2009
 - Demonstrated flight ignition system
 - Ignited at reduced pressure
 - Baseline temperature data collected
- Flight Test March 27, 2010
 - Apogee was 270 km, -6 sigma low, 2 sigma short
 - Stability Anomaly was observed
 - Worst condition during coast after 1st stage separation
 - Stability increased at ~ 10 seconds into flight
 - Motor joint expected cause
- Second Test Flight Planned
 - Implement new joint design
 - Same mass/size payload



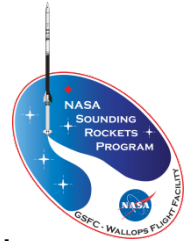
Terrier/Improved Malemute Flight Performance Summary



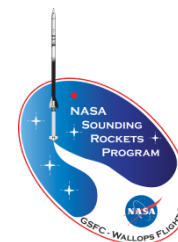
- Lower than expected performance
 - Thrust or drag modals need adjustment
- Stability Anomaly was observed
- Motor pressure was nominal
 - No pressure increase during flight due to spinning environment
- Roll rate 5.2 cps, 1.1 cps high
 - New tailcan/fin arrangement and setting procedure
 - Reduces concern of elevated pressure from erosive burning in a higher spin environment
- Nominal temperature data
 - Relieves concern of inadequate thermal protection in a spinning environment
- Successful Ignition at Altitude
- Flight environment was measured and recorded
 - Support establishing test specifications
- Procedures and operational processes have been established with this flight



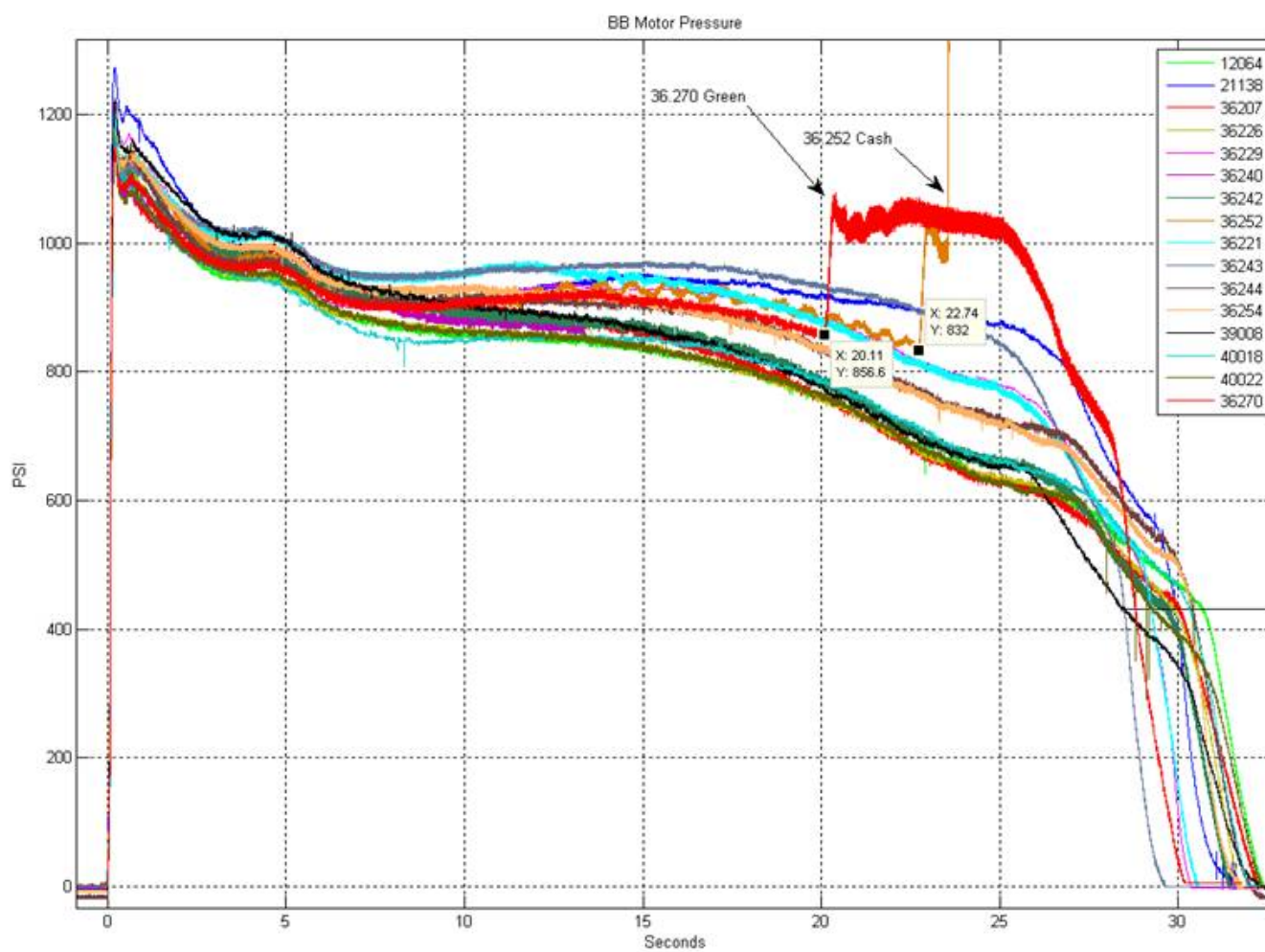
Combustion Instability



- Combustion instability is the amplification or attenuation of acoustic oscillations by solid propellant combustion processes in a rocket motor
 - Higher operating pressures increase likelihood of instability
 - Can be triggered by event such as slag ejection
 - Al content and sizing effect stability
 - Higher Al content (max 20%) damps oscillations
 - AP size distribution effect stability
 - Course (>200 micron) and extra fine can increase likelihood of instability
- Two Black Brant missions experienced an instability in the past year
 - Occurred late in flight, (last 1/3rd)
 - Approximate 20% increase in mean motor pressure at onset
 - Increased acceleration
 - Increase in performance
 - High vibration levels encountered
 - Instability did not “run away”
 - Low spin rate could have contributed to onset of instability
 - Missions were successful

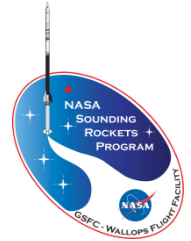


MK1 Pressure Data



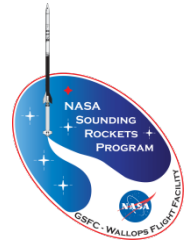
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Combustion Instability

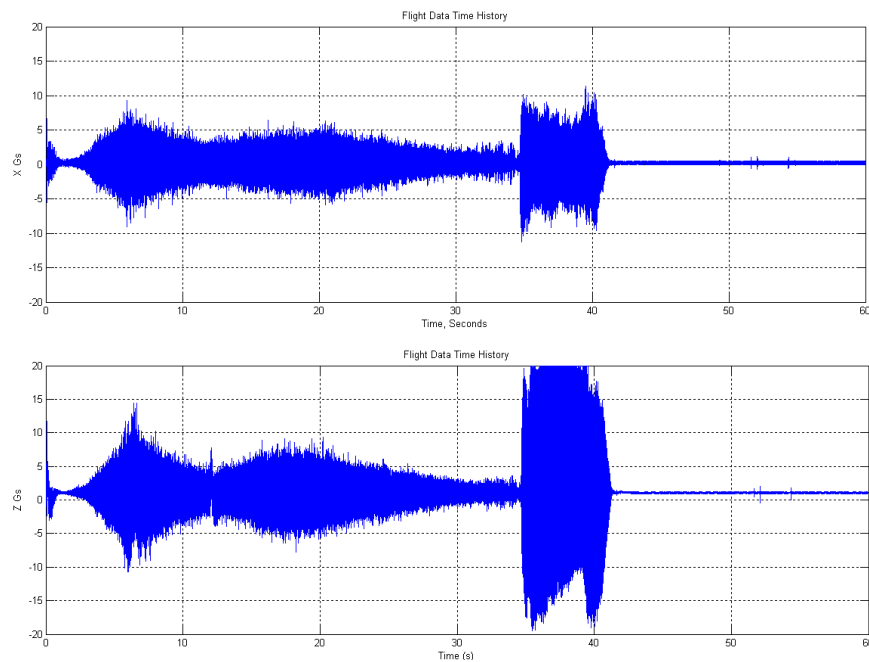


- Cash 36.252, November 13, 2009
 - Instability started at 23 seconds into Brant burn and continued through burnout
 - High vibration
 - Vehicle experienced a low spin rate and increase of flight dynamics caused by 1 fin being set backwards
 - Final spin rate was 1.9 hz
- Green 36.270, May 21, 2010
 - Instability started at 20 seconds into Brant burn and continued through burnout
 - High vibration
 - Vehicle experienced a low spin rate
 - Should have been 2.5hz-3.0 hz, reason not yet known
 - Final spin rate was 2.1 hz

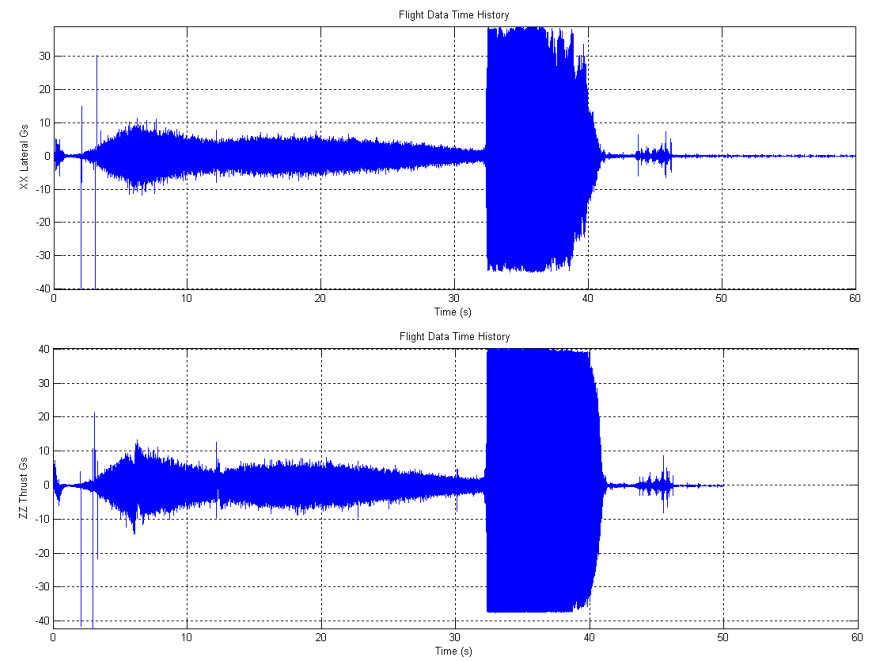
Vibration Data



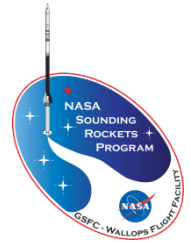
Cash 36.252



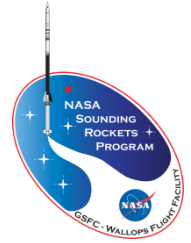
Green 36.270



Combustion Instability Resolution



- Near term fix
 - Reduce operating pressure by opening throat of 13 existing motors by 0.25"-0.30" on diameter
 - Bristol analyzing thermal erosion considerations
 - Bristol calculating pressure and thrust curves
 - Target 4 hz final spin rate on all flights
 - Continue to closely monitor flight performance
- Long term solution
 - Increase throat area and reduce operating pressure
 - Return to standard Brant operating parameters
 - Open throat/redesign nozzle
 - Return to original AP/AL formulation
 - Continue to closely monitor flight performance



Risk Mitigation

- Oriole motors
 - Investigating options to acquire motors
 - Considering participating in Navy procurement
 - Initial plans underway to integrate into a 4 stage configuration
 - Kratos is developing new more efficient fins
 - ATK is developing a TVC nozzle from heritage hardware
 - Oriole FTS is under development for the Navy
- ATACM motors
 - Currently becoming available as a surplus asset
 - Motor has guidance and FTS systems available
 - 24 inch diameter would support large diameter payloads
 - Three stage configuration shows good performance potential
 - MDA is interested in a partnership similar to the Terrier/Improved Malemute